7.0 IMPACTS PROJECTED UNDER OTHER ALTERNATIVES

Projected impacts for Alternatives 2A, 2B, and 3 (No Action) are described in relation to Alternative 1, (Proposed Action), which was discussed in Section 6.0.

7.1 Projected Impacts Under Alternative 2A

Under Alternative 2A, the same number of CBM wells and the same volume of water production would be projected as under Alternative 1. Except for the differences in recharge that would occur based on differences in water handling options, (discussed below), the effects on groundwater resources would be similar to Alternative 1.

The recharge effect was evaluated in this analysis by examining the area of affected surface drainages and the probable range of vertical infiltration rates into the Wasatch Formation below the creeks and ponds. The total discharge from CBM operations would be managed according to the water handling options identified for each sub-watershed under Alternative 2A. Depending on the water handling practices used within each sub-watershed under Alternative 2A, an estimated 28 to 43 percent of the water pumped would be recharged to the shallow groundwater system as a result of infiltration along creeks and below impoundments.

The net recharge is calculated based on the percentage of the produced water handled by each method and its associated estimated percentage recharge (Section 4.5.2 and Table 4-4). The calculated net recharge volume, on a year-by-year basis, was divided by the projected CBM development area within each sub-watershed to obtain an equivalent recharge rate in inches per year (Table 7-1). This infiltration has been characterized as areal recharge, considering the scale and limited detail in the analysis. This recharge under Alternative 2A is compared below with the values input into the model under Alternative 1.

Alternative 2A involves different methods of handling the water produced by CBM operations in certain sub-watersheds. The proportion of water handled by infiltration impoundments and injection would be emphasized under Alternative 2A. Under Alternative 2A, a smaller amount CBM produced water would be discharged to surface drainages than under Alternative 1. More CBM produced water would be handled using infiltration impoundments, containment impoundments, land application disposal (LAD), and injection than under Alternative 1. In addition, there would be a 5 percent reduction from Alternative 1 under Alternative 2A in the produced water handled using LAD in the Crazy Woman Creek sub-watershed, with a corresponding increase in the produced water handled by infiltration impoundments and injection. In the Salt Creek sub-watershed, surface discharge would be eliminated and replaced by increased use of other water handling methods — in particular, infiltration impoundments and injection.

The difference in water handling methods generally results in an increase in infiltration at the ground surface compared with Alternative 1. This increase would be small, with some sub-watersheds (Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River) showing small decreases. Increases in infiltration of between 12 and 28 percent would occur in the Salt Creek, Upper Powder River, Crazy Woman Creek, Clear Creek, Middle Powder River, and Little Powder River sub-watersheds compared with Alternative 1. Under Alternative 2A, this projected increase in surface infiltration would

Table 7-1
Annual Recharge Rate Projected by Sub-Watershed (2002 to 2017) Under Alternative 2A
(Recharge rate applied to developed CBM areas [inches per year])

Sub-watershed	Developed Area (acres)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Upper Tongue River	10,246,277	0.231	0.315	0.415	0.474	0.507	0.539	0.552	0.596	0.594	0.574	0.513	0.464	0.369	0.295	0.210	0.126
Upper Powder River	78,184,723	0.339	0.447	0.527	0.581	0.623	0.645	0.641	0.577	0.515	0.448	0.377	0.295	0.197	0.105	0.071	0.046
Salt Creek	298,848	0.034	0.034	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Crazy Woman Creek	11,776,274	0.214	0.353	0.459	0.543	0.599	0.651	0.679	0.610	0.536	0.480	0.396	0.325	0.247	0.168	0.122	0.079
Clear Creek	17,828,989	0.147	0.217	0.284	0.352	0.412	0.462	0.480	0.486	0.481	0.476	0.412	0.350	0.283	0.224	0.164	0.101
Middle Powder River	6,818,630	0.335	0.354	0.372	0.385	0.377	0.327	0.263	0.288	0.295	0.299	0.274	0.245	0.211	0.175	0.134	0.082
Little Powder River	13,350,050	0.366	0.362	0.354	0.360	0.329	0.301	0.238	0.242	0.247	0.247	0.220	0.198	0.164	0.133	0.100	0.071
Antelope Creek	11,399,624	0.171	0.188	0.212	0.226	0.241	0.245	0.243	0.231	0.222	0.208	0.187	0.164	0.132	0.096	0.078	0.059
Upper Cheyenne River	5,660,490	0.234	0.220	0.207	0.190	0.179	0.156	0.155	0.145	0.131	0.115	0.110	0.076	0.059	0.030	0.030	0.030
Upper Belle Fourche River	35,874,382	0.317	0.307	0.297	0.292	0.287	0.267	0.230	0.220	0.210	0.202	0.185	0.164	0.137	0.088	0.074	0.060

Note: Recharge rates shown include average recharge from precipitation of 0.03 inches per year and projected recharge resulting from water handling methods.

be a small fraction of an inch per year in the various sub-watersheds. These small changes would have a negligible effect on groundwater conditions within these drainages. The percentage of water managed by injection into aquifer units below the coal zone would increase in the Crazy Woman Creek and Salt Creek sub-watersheds..

7.2 Projected Impacts Under Alternative 2B

Under Alternative 2B, the same number of CBM wells and the same volume of water production would be projected as under Alternative 1. Except for the differences in recharge that would occur based on differences in water handling options, (discussed below), the effects on groundwater resources would be similar to Alternative 1.

The recharge effect was evaluated in this analysis by examining the area of affected surface drainages and the probable range of vertical infiltration rates into the Wasatch Formation below the creeks and ponds. The total discharge from CBM operations would be managed according to the water handling options identified for each sub-watershed under Alternative 2B. Depending on the water handling practices used in each sub-watershed under Alternative 2B, an estimated 21 to 30 percent of the pumped water would be recharged to the shallow groundwater system as a result of infiltration along creeks and below impoundments.

The net recharge is calculated based on the percentage of the produced water handled by each method and its associated estimated percentage recharge, as described in Section 4.5.2 and summarized in Table 4-5. The calculated net recharge volume, on a year-by-year basis, was divided by the projected CBM development area within each sub-watershed to obtain an equivalent recharge rate, in inches per year (Table 7-2). This infiltration has been characterized as areal recharge, considering the scale and limited detail in the analysis. This recharge under Alternative 2B is compared below with the values input into the model under Alternative 1.

Alternative 2B involves different handling of the water produced by CBM operations in certain sub-watersheds. An upper limit would be set for the proportion of water handled by infiltration impoundments under Alternative 2B, and active treatment for CBM-produced water would be included as a water handling method. Under Alternative 2B, a smaller amount of CBM produced water would be discharged to surface drainages than under Alternative 1. More CBM produced water would be handled using infiltration impoundments, containment impoundments, LAD, and injection than under Alternative 1. In addition, there would be a 5 percent reduction under Alternative 2B from Alternative 1 in the produced water handled using LAD in the Crazy Woman Creek sub-watershed, with a corresponding increase in the produced water handled by infiltration impoundments and injection. In the Salt Creek sub-watershed, surface discharge would be eliminated and replaced by increased use of other water handling methods — in particular, infiltration impoundments and injection.

The difference in water handling methods for Alternative 2B generally results in a small change in infiltration at the ground surface compared with Alternative 1. The changes in infiltration associated with Alternative 2B are generally small, with the largest increases in infiltration occurring in the Crazy Woman Creek, and Middle Powder River sub-watersheds. The Upper Tongue River, Salt Creek, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River sub-watersheds show small decreases in infiltration of up to 6 percent. Under Alternative 2B, this projected increase in infiltration would

Table 7-2
Annual Recharge Rate Projected by Sub-Watershed (2002 to 2017) Under Alternative 2B
(Recharge rate applied to developed CBM areas [inches per year])

Sub-watershed	Developed Area (acres)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Upper Tongue River	10,246,277	0.174	0.235	0.306	0.349	0.373	0.395	0.405	0.436	0.435	0.421	0.376	0.341	0.273	0.220	0.159	0.099
Upper Powder River	78,184,723	0.254	0.333	0.391	0.430	0.460	0.476	0.473	0.427	0.381	0.333	0.281	0.222	0.151	0.085	0.059	0.041
Salt Creek	298,848	0.033	0.033	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Crazy Woman Creek	11,776,274	0.150	0.240	0.309	0.364	0.401	0.435	0.453	0.408	0.359	0.323	0.268	0.222	0.171	0.120	0.090	0.062
Clear Creek	17,828,989	0.112	0.160	0.207	0.254	0.296	0.331	0.344	0.348	0.345	0.341	0.296	0.253	0.206	0.166	0.123	0.080
Middle Powder River	6,818,630	0.269	0.284	0.298	0.309	0.302	0.263	0.212	0.232	0.237	0.240	0.221	0.199	0.172	0.143	0.112	0.071
Little Powder River	13,350,050	0.237	0.235	0.230	0.234	0.215	0.197	0.158	0.161	0.164	0.164	0.147	0.134	0.113	0.094	0.073	0.055
Antelope Creek	11,399,624	0.150	0.165	0.186	0.198	0.211	0.215	0.212	0.202	0.195	0.182	0.165	0.145	0.117	0.086	0.071	0.054
Upper Cheyenne River	5,660,490	0.205	0.193	0.182	0.167	0.158	0.138	0.137	0.128	0.117	0.103	0.098	0.069	0.054	0.030	0.030	0.030
Upper Belle Fourche River	35,874,382	0.317	0.307	0.297	0.292	0.287	0.267	0.230	0.220	0.210	0.202	0.185	0.164	0.137	0.088	0.074	0.060

Note: Recharge rates shown include average recharge from precipitation of 0.03 inches per year and projected recharge resulting from water handling methods.

average a small fraction of an inch per year in the various sub-watersheds. These small changes would have a negligible effect on groundwater conditions within these drainages. The percentage of water managed by injection into aquifer units below the coal zone would increase in the Crazy Woman and Salt Creek sub-watersheds.

7.3 Projected Impacts Under Alternative 3

Alternative 3 (No Action) assumes that no new federal CBM wells would be completed, except for in areas of potential drainage. Water handling options would be same as under Alternative 1 and would result in a substantial reduction in projected new CBM wells, from 39,367 to 15,458. Except for the differences discussed below, the effects on groundwater resources would be similar to Alternative 1.

Under Alternative 1, the largest numbers of new federal CBM wells would be drilled in the Upper Powder River and Upper Belle Fourche River sub-watersheds (24,898 of 39,367 projected wells under Alternative 1). The exclusion of federal wells from these sub-watersheds under Alternative 3, represents a 77 percent reduction in the Upper Powder River sub-watershed (14,531 wells) and a 43 percent reduction in the Upper Belle Fourche River sub-watershed (2,531 wells). The percentage reduction in wells also would be great in the Middle Powder River sub-watershed, where the reduction would be 79 percent (or 757 wells). More than 1,000 wells also would be eliminated in each of the following sub-watersheds: Crazy Woman Creek (1,986 wells); Clear Creek (1,265 wells); Little Powder River (1,076 wells); and Antelope Creek (1,041 wells). Relatively lower percentage reductions in wells would occur in the Upper Tongue River sub-watershed (17 percent) and in the Clear Creek sub-watershed (34 percent).

Water handling options would be the same as under Alternative 1. Depending on the water handling practices used within each sub-watershed, an estimated 15 to 33 percent of the groundwater produced from CBM operations would recharge the coal zone aquifer or higher aquifer units (Table 4-1).

Although water production would decline substantially in all sub-watersheds under Alternative 3, the percentage reduction in water production would be less than the percentage reduction in wells, compared with Alternative 1. Under Alternative 3, individual wells would yield more water to maintain sufficient drawdown and allow methane to be produced. Water produced was not modeled under Alternative 3.

The extent of drawdown in the coal units would also change. The greatest change would occur in the sub-watersheds with the largest percentages of federal wells. The areal extent of the 25-foot drawdown contour would tend to decrease in areas where large concentrations of federal wells were projected to be drilled under Alternative 1, for example in the Upper Powder River and Upper Belle Fourche River sub-watersheds. It is less likely that state and fee wells would be completed around the large undeveloped federal blocks unless there would be enough wells to maintain adequate drawdown and produce methane.

The volume of produced water that would recharge shallow bedrock and alluvium would diminish proportionately with the decline in water production. The areal extent of recharge would be reduced to exclude areas that would have contained new federal CBM wells, such as in the Upper Powder River, Upper Belle Fourche River, and Crazy Woman Creek sub-watersheds.The extent of drawdown in the coals would be considerably less as a result of the lack of development under Alternative 3, resulting in less drawdown in the overlying Wasatch sands within areas that would have contained high concentrations of federal wells under Alternative 1.